aScope

NW

NORTHWEST INSTRUMENT SYSTEMS, INC.

USER'S MANUAL

MODEL 85
DIGITAL MEMORY OSCILLOSCOPE

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PREFACE

INTRODUCTION

This manual describes the operation of the Northwest Instrument Systems, Inc. Model 85 aScope Digital Memory Oscilloscope.

This manual is divided into eight sections:

Section I	Section I presents an introduction to the Model 85 aScope Digital Memory Oscilloscope.
Section II	This section helps you install your Model 85 aScope , and start using it right away.
Section III	This section details the operation of the Model 85 aScope , providing information on the use of the oscilloscope.
Section IV	The fourth section describes the Model 85 aScope menus.
Section V	This section describes the digitizing techniques used by the Model 85 aScope.
Section VI	This section describes how to write your own control programs.
Section VII	This section provides details of the Model 85 aScope hardware.
Section VIII	Model 85 aScope specifications are provided in this section.

CONVENTIONS

There are references in this manual to control characters. ASCII control characters are designated by the use of an up-vee and character, I.E.: ^C means control-C (hold the control key down while pressing the C key).

ELECTROMAGNETIC EMISSIONS

The Model 85 aScope Digital Memory Oscilloscope has been designed to minimize emitted and conducted electromagnetic energy. Tests have shown that when properly used inside an Apple II Plus computer which meets FCC Class B emission standards, the Model 85 meets or exceeds applicable standards. Each owner is subject to non-interference requirements of Section 15.803 which, in effect, states that the operator of a computing device may be required to stop operating his device if it is found that the device is causing harmful interference and it is in the public interest to stop operation until the interference problem is corrected.

Section I

GENERAL INFORMATION

Introduction

The Northwest Instrument Systems, Inc. Model 85 aScope Digital Memory Oscilloscope is a dual-channel, fully programmable, digital memory oscilloscope.

In this section, we'll describe the Model 85 aScope in general terms. You can find some background information about digital memory oscilloscopes in Section V. Installation information is provided in detail in Section II of this manual.

The Model 85 aScope

The Model 85 aScope is a digital memory oscilloscope that's designed to work with an Apple II, Apple II+, or Apple IIe computer. The Apple computer must have a Disk II, display, 48K of memory, and the DOS 3.3 operating system.

Unlike conventional oscilloscopes, the Model 85 aScope is completely programmable. That is, there are no knobs to turn or buttons to push. Instead, the Model 85 aScope is controlled by the Apple through programs. The standard Model 85 aScope system operating software shipped with the instrument allows you to set up and operate the oscilloscope from the Apple keyboard. Section VI of this manual describes how you can control the Model 85 aScope however you like from your own programs. In any case, once the operating software is loaded, attach one or two probes to the back of the Apple, and you've got a working DC-to-50 MHz oscilloscope.

One of the things that makes the Model 85 aScope

superior to conventional oscilloscopes is its ability to store and retrieve waveforms to and from disk. Another is its capability to print waveforms on a printer for permanent storage. And, the Model 85 aScope can average successive frames of a waveform to remove random noise. However, in most other aspects the Model 85 aScope works just like a conventional scope.

The Model 85 aScope is a "digitizing" oscilloscope, in that analog information received by the probe is sampled very rapidly, and digitized, thus turning the analog information into binary ones and zeros. The Model 85 aScope software then changes the ones and zeros into a waveform presented on the Apple monitor.

The trace generated by the Model 85 aScope is made up of a string of dots on the monitor. The dots follow precisely the pattern made by the incoming analog signal. Figure I-1 illustrates a waveform generated by the Model 85 aScope. Although the dots do not make up a solid line as in conventional oscilloscopes, they're very easy to see and measure. In addition, the normal oscilloscope graticule is present (if you want it to be).

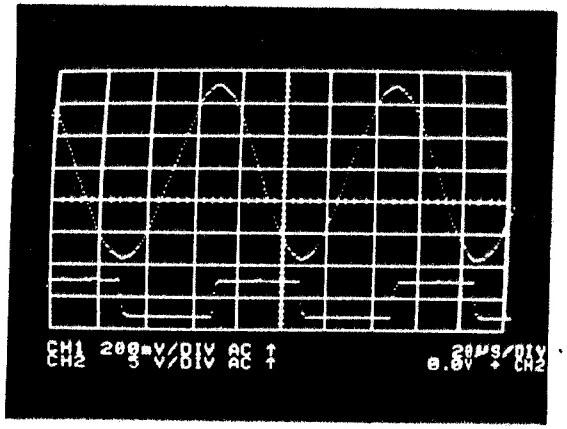


Figure I-1. A sample of the Model 85 aScope waveform.

As you can see in Fig. I-1, the graticule is made up of 8 vertical and 10 horizontal divisions. There are five minor divisions per major division indicated on the centerline of each axis.

Section II

GETTING STARTED

Introduction

This section is intended to help you become familiar with the Model 85 aScope hardware and the oscilloscope mode of its system operating software. After reading this section and following the instructions you will have:

- Installed the Model 85 aScope inside your Apple.
- Installed and properly configured the Model 85 aScope operating system software.
- Connected a signal to the inputs of the Model 85 aScope.
- Acquired and displayed a waveform on the Apple display.
- Read and understood the readout information at the bottom of the display.

In the sections that follow, you will learn how to control the oscilloscope, how to use its unique features through the Operations Menu, how to write programs to control the oscilloscope hardware, and many other important aspects of using your Model 85 aScope.

Installing the Model 85 aScope Hardware

The Model 85 aScope may be installed in either the Apple II, II+, or Apple IIe. Apple II and II+ installation is discussed first, followed by Apple IIe.

INSTALLATION IN APPLE II AND II+

In the following procedures, all references to the Apple II+ also include the Apple II.

CAUTION!

Always disconnect power from the computer before opening the Apple cover or attempting to install or remove the Model 85 aScope.

The model 85 aScope is shipped ready to install in an Apple II+, as shown in Fig. II-1.

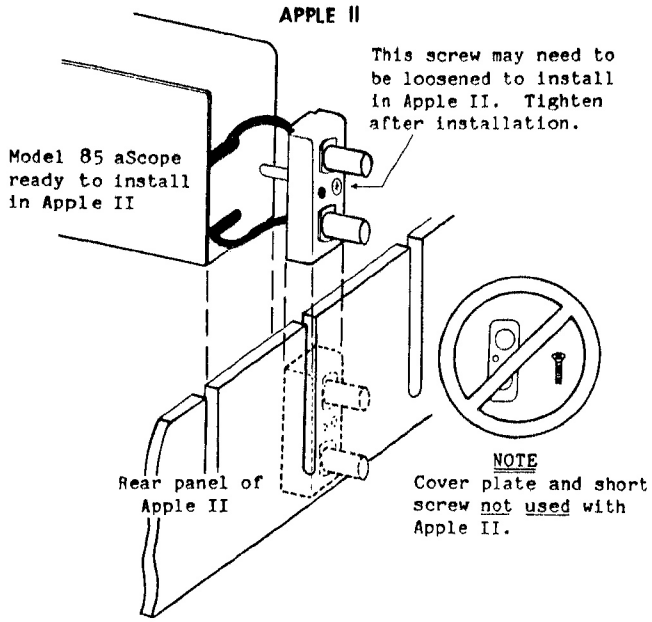

APPLE II
This screw may need to be loosened to install in Apple II. Tighten after installation.
Model 85 aScope ready to install in Apple II
Rear panel of Apple II
NOTE
Cover plate and short screw not used with Apple II.

Fig. II-1. Installation in an Apple II+

1. Pop up the right and left rear corners of the top cover. Do not pull up any farther than is required to disengage the cover from the computer. Slide the top cover toward the back of the computer until the front edge of the top cover clears the front computer face where the keyboard resides. Lift the cover away.

2. Observe the peripheral slots at the back of the computer. These slots are numbered from 0 to 7, left to right, when viewed from the front of the computer. The Model 85 aScope should be installed in slots 2 and 3 (the third and fourth slots, counting from the left). Two other slot pairs are available, but the program CONFIGURE MODEL 85 SOFTWARE must be run as described later in this section.

3. Install the Model 85 aScope by holding the instrument directly above slots 2 and 3, with the BNC connectors for the probes positioned to the rear of the computer. Lower the Model 85 aScope slowly into the computer. The tabs on the probe connector bracket will fit into the opening in the back wall of the computer. The BNC connectors and their bracket will protrude from the back of the computer.

4. Slowly lower the intrument until the two printed circuit boards reach the slots. Push gently but firmly downward to fit the circuit board edge connectors into the slots. If the connectors do not mesh easily with the peripheral slots, it may be necessary to loosen the long screw that holds the connector bracket to the Model 85 aScope. A slight rocking front- to-back of the instrument may help also, but never twist or rock the instrument side-to-side as this may damage the instrument or the slots. If you have difficulty, something is probably wrong. Reconsider what you're doing.

5. Replace the Apple top cover. Slide the cover from back-to-front, and when aligned, press down on the left and right rear corners. You should hear the corners pop into place.

6. In some cases, the Model 85 aScope box may come close to or actually touch parts of other installed circuit boards. The aluminum box is anodized with a clear, hard coating and is thus electrically insulated and durable, but it is best to maintain some separation from other boards.

INSTALLATION IN APPLE IIe

CAUTION!

Always disconnect power from the computer before opening the Apple cover or attempting to install or remove the Model 85 aScope.

Location of the Model 85 aScope

The Apple IIe peripheral slots are numbered 1 to 7, left to right, when viewed from the front of the computer. THIS IS DIFFERENT FROM THE APPLE II NUMBERING SCHEME. On all Apple versions, the Model 85 aScope is normally installed in the peripheral slots numbered 2 and 3. It may also be installed in the slots numbered 4 and 5, but the program CONFIGURE MODEL 85 SOFTWARE must be run as described later in this section.

The CONFIGURE MODEL 85 SOFTWARE program's screen display contains a reference to a slot 0. The Apple IIe does not have a slot number 0. All other slot number references are correct.

Hardware Installation

Fig. II-2 shows the Model 85 aScope being installed in an Apple IIe. The paragraphs following describe installation details.

1. Install the Model 85 aScope by holding the instrument directly above the peripheral slots with the BNC connectors for the probes positioned to the rear of the computer. In the Apple IIe, if the Model 85 aScope is installed in slots 4 and 5, the BNC connectors will be offset slightly to one side to line up with the nearest opening in the Apple IIe rear panel.

2. As you lower the instrument guide the BNC connectors into the rear panel opening. Push gently but firmly downward to fit the circuit board edge connectors into the slots. A slight rocking front-to-back of the instrument may help, but never twist or rock the instrument side-to-side as this may damage the instrument or the slots. If you have

difficulty, something is probably wrong. Reconsider what you're doing.

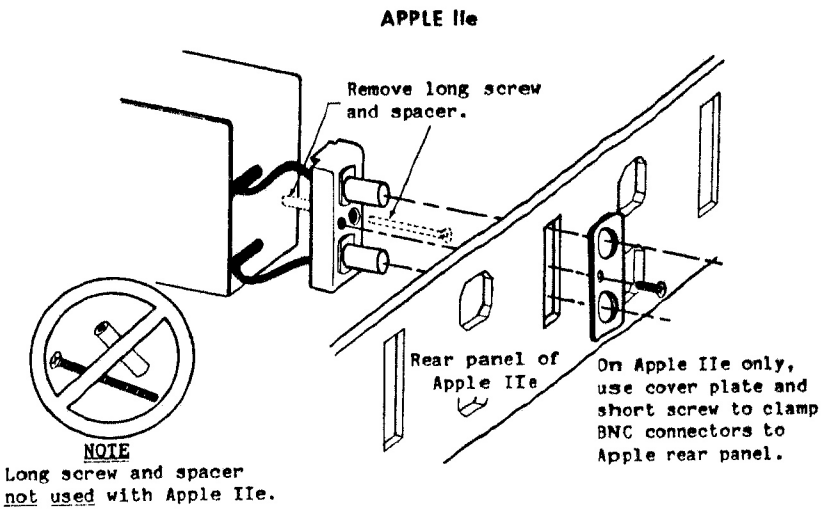

APPLE IIe
Remove long screw and spacer.
Rear panel of Apple IIe
On Apple IIe only, use cover plate and short screw to clamp BNC connectors to Apple rear panel.
NOTE
Long screw and spacer not used with Apple IIe.

Fig. II-2. Installation in an Apple IIe.

3. Replace the Apple top cover. Slide the cover from back-to-front, and when aligned, press down on the left and right rear corners. You should hear the corners pop into place.

4. In some cases, the Model 85 aScope box may come close to or actually touch parts of other installed circuit boards. The aluminum box is anodized with a clear, hard coating and is thus electrically insulated and durable, but it is best to maintain some separation from other boards.

APPLE IIe 80-COLUMN VIDEO DISPLAY

Firmware

On the Apple IIe, the 80-column video display firmware must be turned off to operate the Model 85 aScope. There several ways to accomplish this.

CAUTION!

Always disconnect power from the computer before opening the Apple cover or attempting to install or remove any circuit boards.

To turn off the Apple IIe 80-column video display, follow any ONE of the following procedures:
Either

1. Remove the 80-column display board from its socket.

or,

2. Turn power to the Apple IIe OFF, then back ON. The display board will power-up in the OFF mode.

or,

3. Press and hold the (OPEN APPLE) key; While holding the (OPEN APPLE) key, press and hold the (CONTROL) key; While still holding the first two keys, press the (RESET) key. You are now holding down all three keys. This will reboot the Apple IIe and turn the display board OFF.

Hardware

On some Apple IIe versions, mounting the Model 85 aScope in slots 2 and 3 will interfere with the Apple 80-column video display board. With these versions, the Model 85 aScope should be installed in slots 4 and 5.

Probe Attachment

Two probe sockets (BNC jacks) are now located on the rear panel of the Apple. The upper-most jack is for Channel 1, while the Channel 2 jack is just below.

Probes. The Model 85 aScope has an input impedence of 1 M and 20 pF. Use probes whose compensation can be matched to the Model 85 aScope. When measuring

signals with frequency content greater than 25 MHz, it is recommended that you use a x10 attenuated probe with a bandwidth greater than 100 MHz.

Installing the Software

Your Model 85 aScope digital memory oscilloscope system is shipped with one 5.25 inch flexible disk labeled "System Operating Software". This disk is formatted according to Apple Disk Operating System DOS 3.3.

NOTE

The disk that is supplied with the Model 85 aScope requires the same special handling and attention that any computer disk requires. This means that the disk should not be exposed to significant heat or cold, should not be bent or handled roughly in any manner, and you should never touch the surface of the disk proper.

Before using the disk, you should make a back-up copy. The "COPYA" program on your DOS 3.3 System Master disk will do this. Keep one of the copies in a safe place in case something should happen to the original. You should also make a habit of backing up any disks containing important waveform data.

Insert the disk into Drive 1 of your system and turn on the computer. If you have the Autostart ROMs installed in your Apple, the software will automatically be loaded. If you do not have the Autostart ROMs, then go through your usual procedure for booting a disk, such as "6^P" or "IN#6" for slot six.

In order to control the Model 85 aScope hardware, the system operating software must be set up for the

correct slots. The software is shipped set up for the hardware to be installed in slots 2 and 3. If you choose, you can also install the Model 85 aScope in slots 0 and 1 (Apple II+ only), or slots 4 and 5. If you do choose some slot combination other than 2 and 3, you must reconfigure the system software. To do this, enter BASIC and run the program "CONFIGURE MODEL 85 SOFTWARE" or, if you are using Integer BASIC, "CONFIGURE MODEL 85 SOFTWARE I". The program will tell you which slots the software is configured for and give you options for changing slots.

NOTE

If the software is configured for hardware slots other than those in which the hardware is installed, or if the Model 85 aScope is not installed at all, the software will appear to work, but no waveforms will be displayed.

Fig. II-3 illustrates the Configure program display.

If you're operating in Integer BASIC, you should load the the program called "HELLO I" from the Model 85 aScope operating software disk, and then save, the program to the same disk under the name "HELLO". The disk will now automatically boot from Integer BASIC. A copy of the original Applesoft program "HELLO" is saved on the disk under the name "HELLO A".

As the disk begins loading, the Model 85 aScope logo will be displayed. After a few more seconds, the oscilloscope mode will be turned on and a readout display of the current set-up file will appear at the bottom of the screen.

All the operating software for the Model 85 aScope is loaded when the system is booted up: No routines are loaded later. Therefore, once the system is up and running, you can remove the system disk and insert

any other 16 sector DOS 3.3 disk.

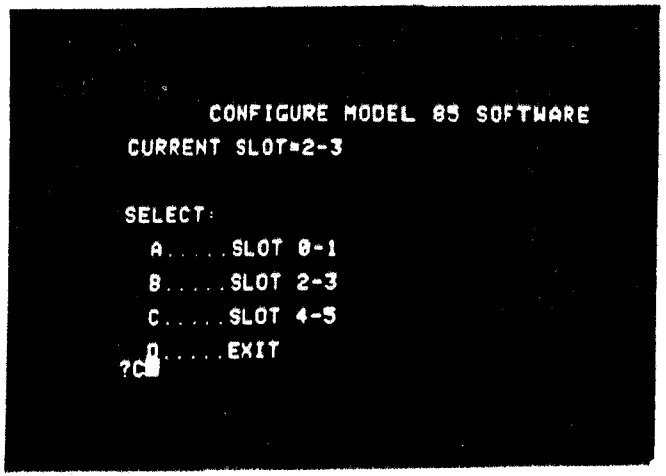


Figure II-3. The Configure program display.

Connecting Signals

The signal inputs to the Model 85 aScope are the two BNC-type connectors on the back of the instrument. The connectors are accessible from the back of the Apple. A function generator or other source of known, repetitive signals will be very helpful in using the Model 85 aScope for the first time. The signal source should have a signal output level between 100 mV and 5 V, and a frequency between 100 Hz and 10 MHz. The Model 85 aScope, of course, is capable of a wider range of signals than these, but this range will be adequate for setting the system up.

Any standard oscilloscope probe can be connected to

the Model 85 aScope inputs. The Model 85 aScope has an input impedence of 1 MΩ and 20 pF, and probes should be used whose compensation can be matched to this impedence. As the risetime of the scope and probe combination is the square root of the product of the scope risetime and the probe risetime, you should use a x10 ("times ten") attenuating probe (which generally has a much higher bandwidth than a x1 probe) at frequencies above 25 MHz.

Connect your signal source to the Channel 1 input. The set-up of the Model 85 aScope is programmable and has been set up by a file which is loaded during the boot process. For most signals of the type suggested, you should see a waveform displayed on the screen at this point. A flashing "*" goes off and on each time the display is updated. If you are seeing only horizontal lines, the trigger level needs to be set. This procedure is covered in the next section.

Reading the Display

Below the graticule there are two lines of set-up readout information. Fig. II-4 shows a sample of the readout information.

On the left side of the readout information are two lines describing the state of the Channel 1 (CH1) and Channel 2 (CH2) vertical systems. In the example shown in Fig. II-3, CH1 is set up for a calibration of 100 mV/DIV, AC coupling of the input, and normal (upright) display. CH2 is set the same as CH1.

At the right side of the screen, the trigger and timebase data is displayed. For this example, we're triggering off the signal from Channel 1 on a positive slope crossing 0.00 mV. The waveform is acquired and displayed with a calibration of 1 us/DIV.

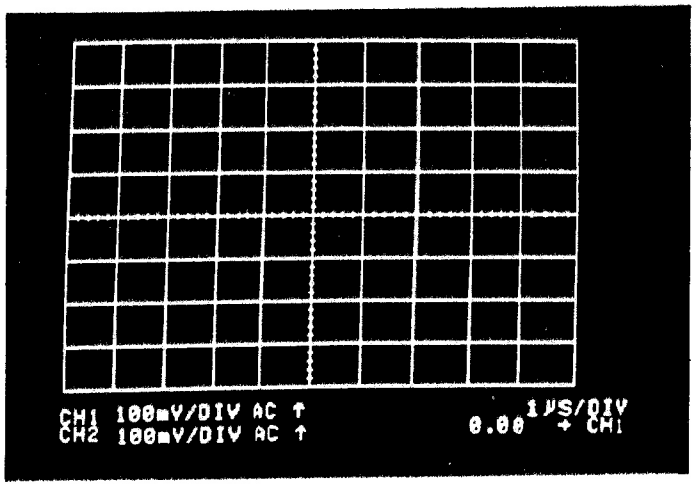


Figure II-4. Model 85 aScope readout information.

Changing the Display

There are a number of things you can do to see how Model 85 aScope operation can be changed from the Apple keyboard.

- You can get started by pressing the "G" key on the Apple keyboard. (If your Apple has been modified to use both upper- and lower-case letters, use the shift-lock key to assure that you use upper-case letters with the Model 85 aScope.) As you can see, the "G" key turns the graticule on and off.

- Now, press the "S" key. You'll notice that the status area has changed. That's because the "S" key turns the Channel 1 display off. Press "S"

again and Channel 1 information comes back. Try pressing "H". The "H" key turns the Channel 2 display off and on.

- By turning the input channel displays off and on, you can identify which status lines go with which input channels. Locate the status area for Channel 1, and then press the "2" key on the Apple keyboard. You'll notice that the top line changed from:

CH1 100mV/DIV AC ↑

to

CH1 100mV/DIV DC ↑

The "2" key changes the channel input coupling from AC to DC and back again. The corresponding key for input Channel 2 is "6". Press the "2" key again.

- Now press the "E" key. The "E" key increases Channel 1 input sensitivity. You'll notice that when you press the "E" key, the status area for Channel 1 indicates a change in the "mV/DIV" value. Press the "D" key once, and the input sensitivity value changes back to its original value.

- Take a look at the time base status for Channel 1 (on the right side of the display). You'll see the following line:

1us/DIV

The "1us/DIV" means that a sweep speed of 1 microsecond/division is selected. Press the

left arrow key in the Apple cursor control area. You'll notice that a slower sweep speed has been selected. Press the right arrow key, and the sweep speed returns to 1 us/DIV.

- Just below the "1us/DIV" line is a line indicating the trigger level voltage, polarity, and source. If you'll press the ";" key (which also has the "+" character on it), the polarity indicator will change. The trigger voltage can be moved higher or lower by pressing the "O" or "L" keys, respectively. The trigger source can be changed from Channel 1 to Channel 2 by pressing the "P" key.

By now you should have some idea of what the Model 85 aScope looks like, and a general idea of how it works. However, the capabilities of the Model 85 aScope far exceed what we've described thus far. We'll tell you in greater detail about how to control the Model 85 aScope oscilloscope in the next section.

Section III

CONTROLLING THE MODEL 85 aSCOPE

Introduction

The Model 85 aScope is controlled by software; the software supplied with the instrument, or your own. When you use the software supplied with the Model 85 aScope, the oscilloscope is controlled from the Apple II keyboard, shown in Fig. III-1. Or, you can create your own controlling software (as outlined in Section VI) and not use the Apple keyboard at all. In this Section, we'll describe how to control the Model 85 aScope from the Apple keyboard.

Those keys highlighted in bold lines in Fig. III-1 let you set up the oscilloscope and control its actions. You'll notice that there are four groups of controlling keys. The left-most group control the Channel 1 vertical input. The center group control Channel 2 input. The group starting with the "0" key controls the timebase and trigger selection. And, the horizontal position of the trace is controlled by the "<" key group. In addition to the four key groups, there are six keys that perform special functions. And, the REPEAT key can be used with all other keys to speed the change.

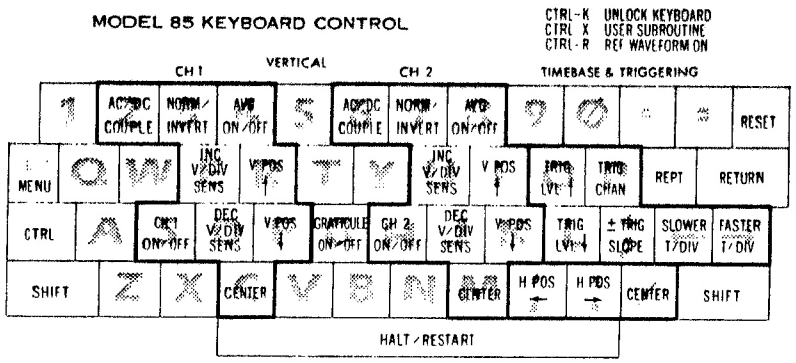


Figure III-1. The Apple keyboard.

Channel 1 Vertical Group

This group of keys controls the input parameters for Channel 1. The following list describes each key.

Key	Function
S	Channel 1 ON/OFF
2	AC/DC Input Coupling
3	Normal/Invert Trace
4	Averaging ON/OFF
D	Decrease Input Sensitivity
E	Increase Input Sensitivity
R	Move Trace Up
C	Center Trace
F	Move Trace Down

CH 1 ON/OFF

Channel 1 ON/OFF. The "S" key turns the Channel 1 display on or off. Any time the channel is turned on, the bottom part of the display provides the state of the channel input parameters. For example:

CH1 100mV/DIV DC ↑

indicates that Channel 1 is on, that vertical sensitivity is set to 100 mV/division, that the channel is DC coupled, and that the trace is in a normal mode. If the arrow were pointing down (↓), the trace would be inverted.

AC/DC COUPLE

AC/DC Input Coupling. The "2" key selects the coupling method for Channel 1 (either AC or DC). The coupling will always be reflected in the status area shown in the lower portion of the monitor. The input coupling corresponds to the way the signal is connected to the input amplifiers. When the signal is "AC" coupled, only the AC components of the signal are passed through. While this is fine for faster AC signals, some signals, such as slow square waves, will show a tendency to droop toward ground. DC coupling passes both the AC and DC components of the signal. Some signals may not appear on the screen or may move around as attenuator settings change because of their DC component when the input channel is DC coupled.

NORM/ INVERT

Normal/Invert Trace. When the trace is inverted by pressing the "3" key, the status area shows the fact by displaying a down-arrow (↓). The trace is inverted numerically before being displayed around the current center-line of the display, as set by the position control. The waveform data values are not affected. Pressing the "3" key again returns the trace to normal.

AVG ON/OFF

Averaging ON/OFF. The "4" key turns input averaging on or off. When averaging, the Model 85 starts acquiring signal data at a trigger, and stores 256 samples of that data. That amount of waveform data constitutes a "frame". When averaging, a predetermined number of frames are stored, totaled, and divided by the number of frames. The result is displayed on the monitor. The number of frames to be acquired can be set anywhere from 2 to 255 through a menu command, which is described in Section IV. The display tells when the Model 85 is averaging by placing a "AVG" on the Channel 1 status area.

DEC V/DIV SENS **Decrease Input Sensitivity.** The "D" key decreases vertical sensitivity for Channel 1. The minimum sensitivity for the channel is 5 V/division. Any changes in vertical sensitivity are reflected in the status area. The sensitivity can be changed in steps of 5-2-1. For example, sensitivity can be set to 500 mV, 200 mV, 100 mV, 50 mV, etc. Each division contains 32 possible signal levels, scaled down to 20 displayed lines.

INC V/DIV SENS **Increase Input Sensitivity.** The "E" key increases Channel 1 input sensitivity. The maximum sensitivity is 5 mV/division. Changes in vertical sensitivity are shown in the status area.

V POS ↑ **Move Trace Up.** The oscilloscope trace can be moved up on the graticule from its current position by pressing the "R" key. When the trace is moved up or down, the acquired and stored data is not changed, only the plotted position of the middle of the data range.

The input data is stored internally as numerical values from 0 to 255. System ground is normally represented as 128 (halfway between 0 and 255), and is plotted at the center of the screen. When the position is changed, all data values remain unchanged but are plotted as shifted up or down. Signals which exceed the internal storage range of 0 to 255 are clipped to those values, and generally plot as straight lines at the limits of the display region.

CENTER **Center Trace.** The "C" key returns the plotted position of the center of the data range to the middle of the graticule.

V POS ↓ **Move Trace Down.** The "F" key moves the Channel 1 trace down within the graticule.

Channel 2 Vertical Group

The Channel 2 vertical group works in exactly the same way as the Channel 1 group. The following list defines the function of each key.

Key	Function
H	Channel 2 ON/OFF
6	AC/DC Input Coupling
7	Normal/Invert Trace
8	Averaging ON/OFF
J	Decrease Input Sensitivity
U	Increase Input Sensitivity
I	Move Trace Up
M	Center Trace
K	Move Trace Down

Time Base and Triggering Group

This group of keys controls the Model 85 aScope sweep speed and trigger selection. The following list defines the use of each key.

Key	Function
P	Select Trigger Channel
O	Increase Trigger Level Voltage
L	Decrease Trigger Level Voltage
; (+)	Positive or Negative Trigger Slope
<--	Select Slower Sweep Speed
-->	Select Faster Sweep Speed

TRIG CHAN **Select Trigger Channel.** The Model 85 can be triggered from either input channel, as selected by the "P" key. The status area indicates the current channel selection. For example:

0.17V + CH1

indicates that input Channel 1 is the trigger source, and that the trigger will occur on a rising edge at 0.17 volts.

TRIG LVL ↑ **Increase Trigger Level Voltage.** The "O" (letter "oh") key increases the trigger level voltage. When the vertical input channel is set to a scale between 5 mV/division and 200 mV/division, the trigger level can be selected in steps of 10. mV within a range of -1.26 volts to +1.26 volts. When the input channel is set to a scale between 500 mV/division and 5 V/division, the trigger level can be selected in steps of 200 mV within a range of -25.2 volts to +25.2 volts.

You should be aware that the actual trigger level is an approximation of the voltage displayed on the screen, and therefore may not be entirely accurate.

TRIG LVL ↓ **Decrease Trigger Level Voltage.** This key decreases the trigger level voltage in the same way as the "O" key increases the trigger level voltage.

± TRIG SLOPE **Positive or Negative Trigger Slope.** The ";"(+) key on the Apple II keyboard selects the trigger slope for the input trigger channel.

SLOWER T/DIV **Select Slower Sweep Speed.** The Model 85 time base provides accurate timing measurements over more than nine decades, from 10 ns/division to 20 s/division. Each division contains 25 samples. A couple of samples are plotted outside the graticule on either end of the display, for a total of 256 horizontal samples. When operating at sweep speeds slower than 1 ms/division, the Model 85 operates in a real-time mode. When operating at sweep speeds faster than 1 ms/division, the time base operates in an "equivalent time" mode. This requires that the input signal be periodic. Real-time sampling and

equivalent-time sampling are described in greater detail in Section V.

The "<--" key changes the sweep speed to a slower setting. The setting is reflected in the status area at the bottom of the display. The sweep speeds change in a 1-2-5 sequence, i.e. 1 ms, 2 ms, 5 ms, 10 ms, etc.

FASTER T/DIV **Select Faster Sweep Speed.** This key selects a faster sweep speed.

The Horizontal Position Group

This group of keys moves the trace horizontally, just as the vertical position function moves the trace vertically. Only the plotted position changes, not the data. The following lists the function of each key.

Key	Function
, (<)	Move Trace Left
. (>)	Move Trace Right
/	Center Trace

H POS ← **Move Trace Left.** The "," (<) key moves the trace to the left within the graticule.

H POS → **Move Trace Right.** This key moves the trace to the right within the graticule.

CENTER **Center Trace.** The "/" key centers the trace horizontally within the graticule.

Special Function Group

There are six keys that control special functions of the Model 85. The functions are described in the following list:

Key	Function
G	Graticule ON/OFF
Space Bar	Halt/Restart
^K	Unlock Keyboard
^X	User Subroutine
^R	Reference Waveform On
ESC	Operations Menu

G - Graticule ON/OFF. The "G" key allows you to turn the display graticule on or off at will.

Space Bar - Halt/Restart. The space bar on the keyboard lets you halt the acquisition of data, and then restart acquisition at will. To halt acquisition, press the space bar once. When acquisition is halted, the last waveform acquired is continually displayed. When halted, the word "HALT" is shown in the status area.

To restart acquisition, press the space bar again.

^K - Unlock Keyboard. The control-K (^K) key unlocks the keyboard. The Model 85 allows the Apple II keyboard to be locked in order to prevent oscilloscope settings to be accidentally changed. Locking the keyboard is discussed in the next section under the heading "Miscellaneous Menu".

^X - User Subroutine. The control-X (^X) key is used to exit to a subroutine you write. Information on writing and running your own subroutines is provided in Section VI.

^R - Reference Waveform On. The control-R (^R) key is used to display a reference waveform that was previously stored on disk. This function of the Model 85 is described in detail in the next section.

ESC - Operations Menu. The Model 85 Operations Menu is selected by pressing the "ESC" key. Almost all standard functions of the Model 85, other than those of a conventional oscilloscope, are selected from the Operations Menu. The Operations Menu and its sub-menus are described in the next section.

Section IV

MODEL 85 aSCOPE MENUS

Introduction

Most of the Model 85's special functions are controlled through the use of menus. The menu structure is hierarchical in form. That is, sub-menus are selected from the primary Operations Menu. The Operations Menu is selected by pressing the "ESC" key on the Apple keyboard. The following text describes the Operations Menu and the sub-menus.

Operations Menu

Any time during the operation of the Model 85 aScope, you can press the "ESC" key and select an item from the Operations Menu. The Operations Menu is shown in Fig. IV-1.

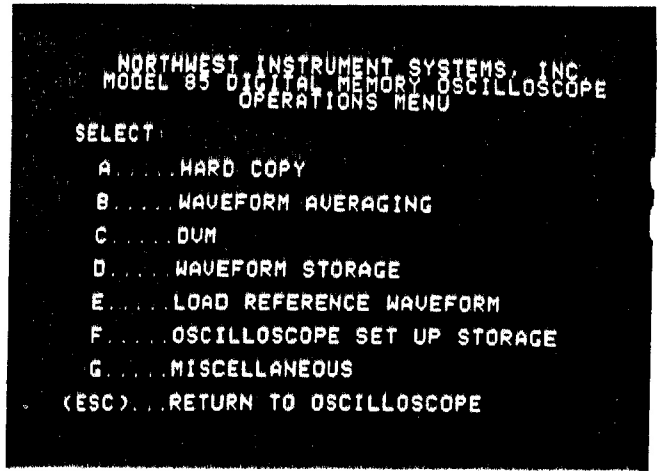


Figure IV-1. The Model 85 aScope Operations Menu.

When the Operations Menu is displayed on the monitor, you can select any of seven items by pressing the appropriate letter key. Or, you can return to normal oscilloscope operation by pressing the "ESC" key.

When a waveform is acquired with averaging, the ESC function to call the Operations Menu is delayed until all the samples are taken and averaged so that the data available for storage, hard copy, DVM, and so forth, is the most recent averaged data.

The seven selections available from the Operations Menu are discussed in order. The Hard Copy, DVM, and Miscellaneous options each have a sub-menu. We'll start with the Hard Copy Menu.

Hard Copy Menu

The Hard Copy Menu lets you select from a variety of options in order to produce a printer copy of the current oscilloscope display, or of any display you've saved on disk. As you can see from Fig. IV-2, you have the option of creating a hard copy on an Epson MX-80 (with the graphics option) or Silentype printer. You can preview the image to be printed, add a label to the image, save the image on disk or retrieve another from disk. And, you can change the printer slot at will. You can return to the Operations Menu by pressing the "ESC" key.

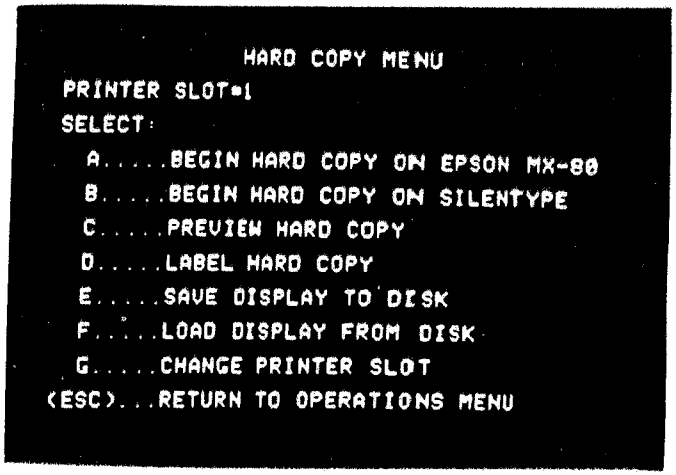


Figure IV-2. The Model 85 aScope Hard Copy Menu.

A - Begin Hard Copy on Epson MX-80. If an Epson MX-80 is used to print hard copies, the printer must have the optional graphics ROM installed. To print a trace that you've acquired, simply press the "A" key. If you're satisfied with the hard copy, and want to return to oscilloscope operations, press the "ESC"

key twice. If you want to return to the Operations Menu, press the "ESC" key once.

NOTE

When you want to print an image on the MX-80, you must make sure that the printer is set to top-of-form. The routine to drive the printer destroys the top-of-form register contents, and therefore assumes that the printer was already at top-of-form. The Model 85 aScope resets the top-of-form register when printing is complete. If you're using an MX-80 through an RS-232 serial port, the top-of-form register is not reset. You'll have to manually adjust the paper and set top-of-form.

B - Begin Hard Copy on Silentype. If you have an Apple Silentype, you can print an image of the display by pressing the "B" key. When the image is printed, press the "ESC" key once to return to the Operations Menu, and twice to return to oscilloscope mode.

NOTE

If you select this option from the Display Menu, but don't have a Silentype connected to the Apple, or if the printer slot is incorrect, the system will hang. If this happens, press RESET and enter CALL 34352 to restart the Model 85 aScope.

C - Preview Hard Copy. You can take a look at the display prior to sending it to the printer by pressing the "C" key. The current waveform display will be shown on the monitor. Pressing any key will return you to the Hard Copy menu.

D - Label Hard Copy. You can add a label to the hard copy before printing it by pressing the "D" key. Adding labels to hard copy can be very valuable, and an easy way to make notations to your pictures. Notations could include dates, names of measurements, or other text which will help document the hard copy. Up to 29 characters of text can be entered.

E - Save Display to Disk. To save a display image on disk, press the "E" key. The Model 85 aScope will ask you what file name you want to use. If you'd like to look at the disk catalog before storing the image, press ^C (control-C) and RETURN. The disk catalog will be listed on the monitor. Press RETURN again to resume entering the file name.

By the way, storing a complete display is not the same as storing a waveform as you can do from the Operations Menu. The only thing saved when you press "E" from the Hard Copy Menu is the display. No usable set-up information is stored.

F - Load Display from Disk. You can load a display that you've previously stored, and that you want a hard copy of, by pressing the "F" key. The Model 85 aScope will ask you what the name of the file is that contains the image. If you need to look at the disk catalog, enter ^C and press RETURN. A note of caution: Saving and then reloading a picture saved from the Model 85 aScope should be no problem, but loading other pictures might cause a problem with the high resolution character generator used to display the readout information. The data for the character generator is "hidden" in otherwise unused space in the Apple's high resolution display memory, and can be scrambled by pictures saved from other sources.

Once the image is loaded from disk, you can create a hard copy by pressing the "A" or "B" keys.

G - Change Printer Slot. The printer output slot can be changed by pressing the "G" key. Notice at the top of the Hard Copy Menu that the current printer slot is always displayed.

ESC - Escape to Operations Menu. You can press the ESC key to return to the Operations Menu.

Other Printer Configurations. If you have a printer other than an Epson MX-80 or Apple Silentype, you can still obtain hard copy output of your recorded waveforms. You need only to save the screen picture onto disk, load your printer driver software, load the picture again from disk, and print it. Other techniques for the more experienced programmer are described in Section VIII.

Waveform Averaging

The Waveform Averaging selection from the Operations Menu allows you to select the number of frames to be averaged. Recall from earlier in this section that a "frame" is 256 samples of a waveform. By pressing "B" from the Operations Menu, you can set the number of frames to be averaged from 2 to 255, as shown in Fig. IV-3.

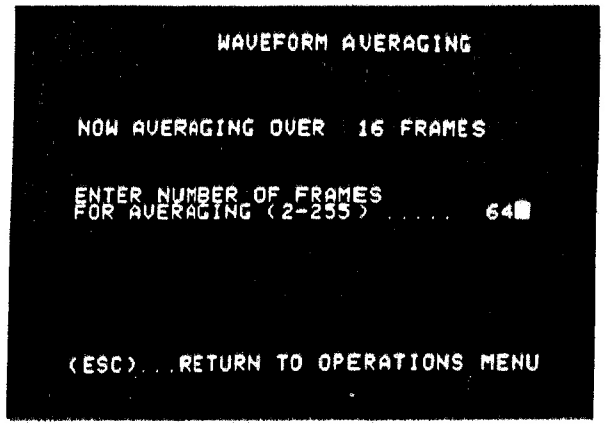

WAVEFORM AVERAGING
NOW AVERAGING OVER 16 FRAMES
ENTER NUMBER OF FRAMES
FOR AVERAGING (2-255) 64
(ESC)...RETURN TO OPERATIONS MENU

Figure IV-3. Model 85 aScope averaging selection.

When the Waveform Averaging menu item is selected by pressing "B", the current number of frames being averaged is displayed, as shown in Fig. IV-3. If you don't want to change the number of frames being averaged, press the "ESC" key and you'll be returned to the Operations Menu. If you do want to change the number of frames, enter a number between 2 and 255, press RETURN, and then press the "ESC" key.

DVM (Digital Voltmeter)

When a waveform is captured in memory, it may be held for as long as necessary and examined in great detail. The Model 85 aScope DVM option provides a method of determining the voltage of any point along a waveform.

When you select the DVM from the Operations Menu, a

DVM Menu is shown on the monitor, as in Fig. IV-4. Since voltage is always specified with respect to a reference potential, you must be able to provide the Model 85 aScope with a reference ground. This reference ground will be used in all DVM calculations until the procedure is repeated.

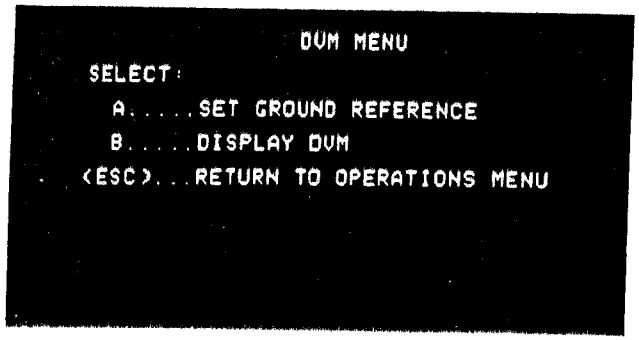


Figure IV-4. The Model 85 aScope DVM menu.

When selecting a ground reference, always measure the ground which is most closely associated with the captured waveform.

Press the "A" key to set a ground reference. The Model 85 aScope will then prompt you to place the input probe on a reference ground, and then type in the appropriate vertical channel number. Once the reference ground has been set, the Model 85 aScope will use that value for all DVM calculations until a new reference ground is selected.

If you don't specify a ground reference potential, and no special ground reference was specified in the

set-up, the system will use a default ground reference. The default ground reference corresponds to a data value of 128 (hex $80) which is normally displayed at the center of the screen. If the trace position is moved from the center of the screen, the apparent position of the ground reference will be moved along with the trace position.

Once the reference ground has been set, press the "B" key. The display will return to the captured waveform. But this time, there will be a "+" in the display, indicating a position on the waveform being measured. In effect, the "+" is a cursor, and as a cursor, its position can be controlled by using the <-- and --> cursor control keys on the Apple keyboard. Move the "+" cursor to the waveform location you want to measure. The voltage for that point in the waveform is displayed just below the graticule on the same line as the readout information for that waveform's channel. A sample of the DVM display is shown in Fig. IV-5.

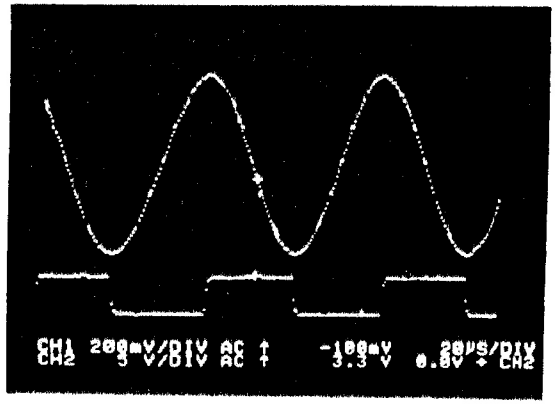


Figure IV-5. A sample of the DVM display.

When you've finished, you can return to the DVM Menu by pressing the "ESC" key, and to the Operations Menu with a second "ESC".

Waveform Storage

The Model 85 aScope is capable of storing waveform data, including the trace and status information, on disk. When you enter "D" from the Operations Menu, you're asked a number of questions, as shown in Fig. IV-6.


```
ENTER FILE NAME: EXPERIMENT 101  9/4/82

SAVE CHANNEL 1 OR CHANNEL 2? (1/2) 1

SAVE AS A BINARY OR TEXT FILE? (B/T) B

SAVE CHANNEL 1 AS A BINARY FILE
NAMED: EXPERIMENT 101  9/4/82

IF CORRECT, INSERT DATA DISK
AND PRESS RETURN.
OTHERWISE, PRESS ESC.
```

Figure IV-6. Model 85 waveform storage questions.

First, you're asked if you'd like to see the waveform before it's stored. Answer Y (yes) or N (no). Next, you're asked in what file you'd like the waveform stored. If you'd like to look at the disk catalog at this time, enter a ^C and press RETURN.

When you've entered the file name, the Model 85 aScope asks you to enter the number of the channel you'd like to save (1 or 2). And, whether you want to save the display in binary or text form.

Once all the information has been entered, the Model 85 aScope verifies by repeating the channel number to be saved, file type, and file name. If everything is correct, you can enter a data disk initialized with DOS 3.3 in the Disk II, and the waveform will be stored. If you decide you want to change something, press the "ESC" key.

Storage Format. When a waveform is stored, a similar format is used for both binary and text files. The first 256 items in the file are the raw data values of the digitized waveform. A value of 127 ($7F hex) or less represents a positive voltage, and 129 ($81 hex) or greater represents a negative voltage. (0 represents the greatest positive voltage, and 255 represents the greatest negative voltage.) Zero volts is represented by 128 ($80 hex). Each value stored corresponds to a sample at a particular time, the first value being the first sample.

Eight additional numbers are appended to the waveform data. In order, they are:

Averaging ON/OFF
Normal/Invert Display
AC/DC Coupling
Vertical Position
Attenuator Setting
Time Base Setting
Ground Reference Level
Probe Setting

Table VI-1 in Section VI provides information for interpreting the values saved for these parameters.

Binary files are $108 bytes long and are saved starting at $F00. Text files are 264 records long. Each record is a three digit number followed by a RETURN so that a text file of waveform data can be treated as a sequential file or as a random access file of record length 4. Leading zeros are not suppressed, so that a number such as 27 is stored as 027.

When the waveform has been stored on disk, the Model 85 aScope returns to the Operations Menu.

Waveform Retrieval

Waveforms that have been stored by using Operations Menu item "D" can be recalled from disk, and used as reference waveforms. To recall a waveform, select menu item "E". You will be prompted by the Model 85 aScope to answer a series of questions, as shown in Fig. IV-7.

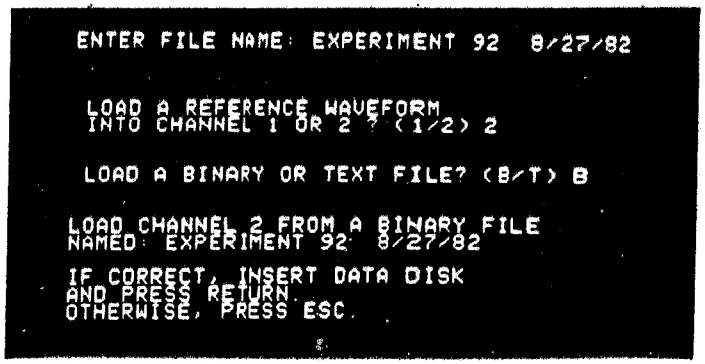

ENTER FILE NAME: EXPERIMENT 92 8/27/82
LOAD A REFERENCE WAVEFORM INTO CHANNEL 1 OR 2 ? (1/2) 2
LOAD A BINARY OR TEXT FILE? (B/T) B
LOAD CHANNEL 2 FROM A BINARY FILE NAMED: EXPERIMENT 92 8/27/82
IF CORRECT, INSERT DATA DISK AND PRESS RETURN.
OTHERWISE, PRESS ESC.

Figure IV-7. Model 85 waveform retrieval questions.

When you're asked to enter a file name, you have the option of looking at the disk catalog first by entering a ^C and pressing RETURN. Once you've entered the file name, you'll be asked into which channel you'd like the wave loaded. Enter a 1 or 2. The system then asks whether the file is in binary or text format.

When you've answered all the questions, the Model 85 aScope will confirm the data, and then retrieve the information. Next, you will be asked if you want the

reference waveform turned on. If you answer "Y" (yes), the reference waveform will be displayed immediately and available for use with the DVM, hardcopy, and so forth.

Using the Reference Waveform. Although the Model 85 aScope is a dual-channel oscilloscope, the reference waveform retrieved from disk exists as what can be thought of as a third channel. In other words, you can still use channels 1 and 2 to gather new information, while the reference waveform exists in local storage.

When you want to display the reference waveform, press ^R. The reference waveform will be displayed in whichever channel position you selected when you retrieved the waveform. To turn off the reference waveform (thus turning on the normal waveform), press the channel on/off corresponding to the replaced channel ("S" for Channel 1 or "H" for Channel 2). In this way, you can acquire new waveforms on one channel, and then compare the new waveform against the reference waveform.

When the reference waveform is turned on, the waveform responds to the position and normal/invert controls of the channel it has replaced. However, none of the attenuator or timebase controls will affect the reference waveform.

When the reference is on, the channel it replaces can still be used as the trigger source. Remember though, that even though the readout of the channel replaced by the reference is not visible, the set-up of that channel will still be in effect if it is used as the trigger source.

The DVM option can be used on the retrieved waveform at any time. When the waveform was retrieved, it brought with it its own reference ground. You can use the DVM normally, except that you won't have to set a reference ground for the retrieved waveform.

Oscilloscope Set Up Storage

When the Model 85 aScope software is initially loaded, all channel options (sensitivity settings, timebase settings, etc.) are set to a default value. If you find yourself using a particular set of options, you can replace the default values with new values by pressing the "F" key from the Operations Menu. Then, the next time you load Model 85 aScope software, the default values are those that you selected. Table IV-1 lists the values and states that are saved.

Table IV-1
Options Stored by "F"

Vertical Channels	Channel ON/OFF
	Averaging ON/OFF
	Invert/Normal
	Position
	Sensitivity Settings
	Ground Reference
	Probe Attenuation
Timebase	Trigger Slope
	Trigger Source
	Trigger Level
	Timebase Setting
	Horizontal Position
Other	Number of Frames to Wait Before Time Out
	Number of Averages
	Graticule ON/OFF
	Disk Slot & Drive
	Printer Slot
	Keyboard Locked/Unlocked

Many of the functions of the Model 85 aScope are set

up by values stored in the file "SETUP 85". If, for some reason, you suspect that the system set-up is causing problems, a copy of the original set-up can be found on the system software disk. You can replace the set-up with the original version by entering these commands from BASIC:

```
BLOAD ORIGINAL SETUP 85
BSAVE SETUP 85, A$9518,L$E8
```

If you have several set-ups you like to use, copy the Model 85 aScope disk and configure each copy for the desired set up.

Miscellaneous

There are a number of items that can be set by selecting the Miscellaneous option from the Operations Menu. When you press "G" from the Operations Menu, the Miscellaneous Menu is displayed, as shown in Fig. IV-8.

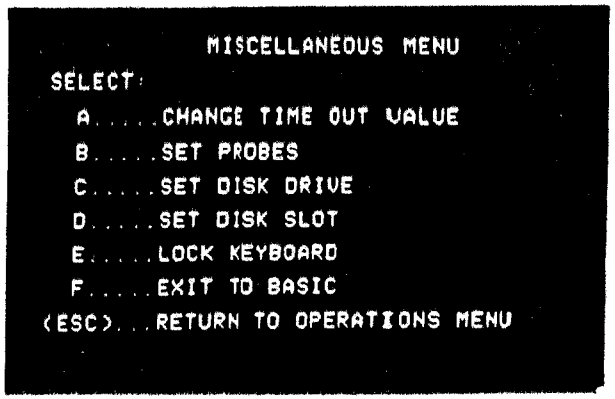


Figure IV-8. The Miscellaneous Menu.

A - Change Time Out Value. Since the Model 85 aScope is an equivalent time sampling system at the faster sweep speeds, there is no way to simulate an "Auto" trigger mode by forcing periodic system triggers as a conventional analog oscilloscope can. To overcome this, the Model 85 aScope waits a specified number of acquisition times for a trigger. If no trigger occurs within the specified time, a DC level is acquired by sampling the active channels four times, and averaging the input. This also allows DC levels to be acquired and displayed.

The amount of time spent waiting for a trigger for time bases of 1 ms/DIV and slower is

(n x 10 x sweep time per division)

where n is the number of acquisition times specified. For sweep speeds 500 us/DIV and faster, the amount of time is

(n x 0.64 seconds).

You can change the time-out value by pressing "A" from the Miscellaneous Menu. You will be given the current time out value, and asked to select a new value ranging from 0 to 255. If you select 0 as the value, a time out will never occur.

Setting the time-out value is important when you are looking at signals of low duty cycle. If, for instance, you are looking at 2 ms pulses occurring at 1 second intervals, you would want to set the time-out value to be high enough so that the system does not time out between pulses, but short enough so that a check could be made to see if the system stops triggering. For this example, a time-out value of 150 on 1ms/DIV would be satisfactory (150 x 10 x 1ms = 1.5 seconds).

B - Set Probes. You can use X10 or X100 attenuating probes with the Model 85 aScope at any time. However, if you do use attenuating probes, you must tell the oscilloscope. Otherwise, the V/DIV value given in the status area will be misleading. The original set-up shipped with the Model 85 aScope assumes that you're using X1 probes. If you want to use X10 or X100 probes, you must enter the Miscellaneous Menu and change probe attenuator values. You won't damage the Model 85 aScope by not setting attenuator values, but the burden rests on you to remember whether you're using attenuated probes, and read the oscilloscope trace accordingly.

When you enter "B" from the Miscellaneous Menu, the monitor displays the current probe attenuation values for each channel, as shown in Fig. IV-9.

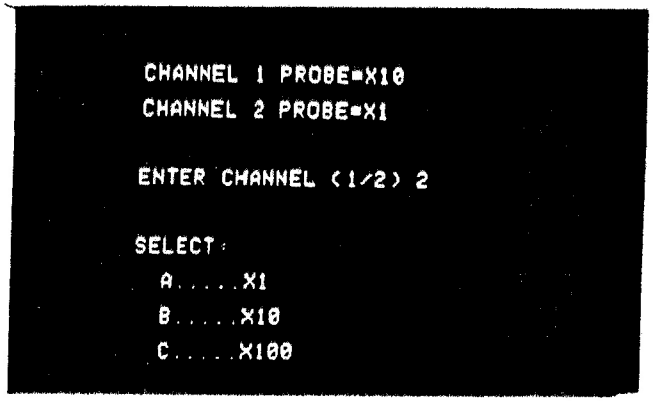


Figure IV-9. The probe attenuation set-up display.

You are then asked which probe channel attenuation value you'd like to change. Enter the channel number, and then select the value.

C - Set Disk Drive. The "C" option tells you the current disk drive being used, and allows you to change to the other drive. This drive number is part of the set-up, and is not modified automatically if you change drives.

D - Set Disk Slot. Selecting item "D" allows you to change disk slots. The disk slot number is part of the set-up, and is not modified automatically if you change slots.

E - Lock Keyboard. This option lets you lock the keyboard and return to the Operations Menu. All menu functions are available, but if the oscilloscope is turned on again, the keyboard is locked until a ^K is

entered. Locking the keyboard prevents inadvertent changing of oscilloscope settings.

F - Exit To BASIC. Selecting "F" from the Miscellaneous Menu does an immediate warm start of DOS, and enters the BASIC language. If you need to return to the oscilloscope, type "CALL 34352" from BASIC.

ESC. By pressing the "ESC" key, you are returned to the Operations Menu.

Section V

DIGITIZING TECHNIQUES

Digital Memory Oscilloscopes

The Model 85 aScope Digital Memory Oscilloscope uses high-speed analog-to-digital (A/D) sampling methods to convert the signal being measured into a binary pattern. The Model 85 aScope A/D conversion system "samples" the analog signal at a very high rate of speed. Each time the analog signal is sampled, the exact voltage of the signal is turned into a binary number. That number is stored in Apple memory, and then converted to a dot on the Apple monitor. The position of the dot on the monitor depends on the time at which the sample was taken, and the relative voltage of the input at that point in time.

The Model 85 aScope can acquire very fast samples of the incoming signal, but the speed of memory and analog-to-digital converters are limited. As a result, the Model 85 aScope acquires waveforms in two distinct ways.

Slow Speeds

At slower speeds, the memory and converter can keep up with the sampling rate, so the data is sampled in "real" time. This means that when a trigger level and slope is detected, the system triggers. Sampling of the analog signal begins and samples are taken at equal intervals in time, so that each digitized data point represents the value of the analog signal at a particular point in time following the trigger. The fastest real-time sampling rate is 25 KHz, corresponding to a time between samples of 40 usec. Since there are 25 equally spaced samples per major division, this rate corresponds to a sweep speed of 1

ms/division.

High Speeds

For the faster time bases -- those faster than 1 ms/DIV -- the Model 85 aScope uses a different sampling method called "equivalent time sampling".

Equivalent time sampling requires an input that is both repetitive and periodic following a trigger point. This is because the oscilloscope acquires only one sample each time the trigger occurs. The Model 85 aScope acquires the first sample immediately following the first trigger. For each subsequent trigger, the time between the trigger and the sample is increased a precise increment. In other words, the Model 85 aScope builds up a picture of the repetitive waveform over a number of sample periods. When the last trigger occurs, the Model 85 aScope reconstructs the appearance of the original waveform from data acquired. Fortunately, most signals of interest are periodic and are easily digitized and displayed by the Model 85 aScope.

Oscilloscope Capability

Digital memory oscilloscopes expand upon the capability of a conventional oscilloscope in a number of ways. First of all, because the input signal has been transformed into a binary state, the input signal can be stored, and then recalled later for display. And, because the input is now represented by numbers, the waveform can be mathematically manipulated. For example, the Model 85 aScope can average sucessive waveforms together, and display the result. The numeric representation can also be used in any number of computations. Finally, you can create a hard-copy of the waveform any time you like.

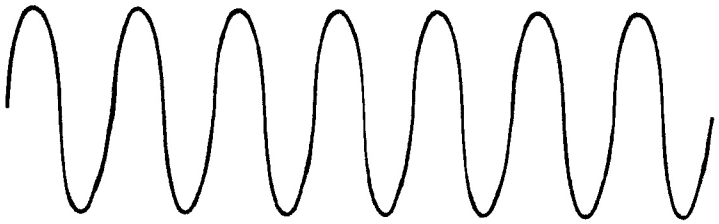
There are some things you must be aware of in using a digital memory oscilloscope. The oscilloscope is turning a waveform that's continuous in time and in

amplitude into a string of numbers that quantize th time and amplitude.. The information contained in t signal between samples, however, is not recorded. Several kinds of errors can result from trying to reconstruct the original waveform from the sampled data. For example, assume that the input waveform was a regular sine wave as shown in Fig. V-1.

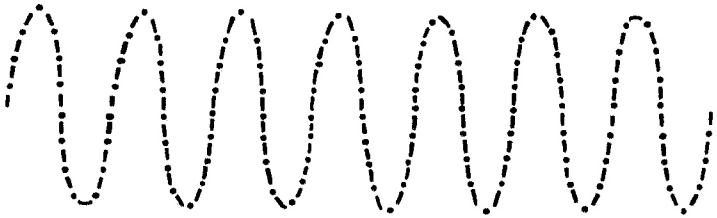
If the original waveform were not sampled often enough (represented by the dots along the waveform), the oscilloscope might reconstruct the waveform as shown below the original. This problem could arise if the input frequency were much higher than acceptable to the oscilloscope. In that case, the input signal would be "under-sampled". In other words, the oscilloscope could not sample the input fast enough to reconstruct an accurate representatio of the incoming waveform. These errors can take several forms and are generally called "aliasing".

In one case, the aliasing is visual. Your eyes and brain will try to connect waveform points which are close together, and thus may imagine curves on a waveform which don't exist. A second form of aliasing would occur if some incorrect mathematical assumption is made, such as that a straight line can be used to connect adjacent samples, when in fact th signal may do no such thing. To avoid undersampling which could lead to aliasing, keep this rule (the "Nyquist criterion") in mind: **the sampling frequency should be at least two times greater than the highes frequency of interest in the signal.**

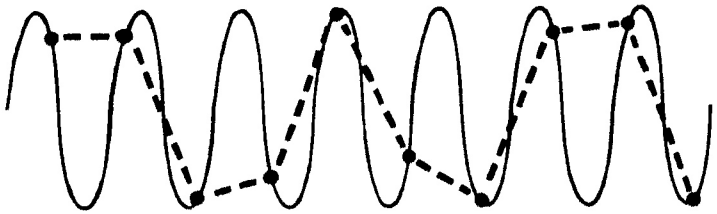
However, in almost all cases, if you know the approximate shape or type of waveform being measured, and set the time base accordingly, you won't have any problems.



Original signal waveform



Proper sampling for reconstructing original signal



Undersampled - unable to reconstruct original signal

● samples
— reconstruction

Figure V-1. The effect of undersampling.

Section VI

WRITING PROGRAMS FOR THE MODEL 85 aSCOPE

Introduction

The software which operates the Model 85 aScope Digital Memory Oscilloscope consists of two parts: Hardware Control Manager, and User Interface. Under most circumstances, the Model 85 aScope is running under the Hardware Control Manager. Only when a key on the Apple keyboard is pressed or an error occurs is the User Interface software called. The Hardware Control Manager is illustrated in Figure VI-1. The User Interface routine is shown in Figure VI-2.

As you can see in Fig. VI-1, the Hardware Control Manager continuously loops while the Model 85 aScope is acquiring information. When called by the User Interface, the Hardware Control Manager sets up the digitizer and acquires input information. The information is processed (according to the options selected), and the display is updated. This cycle is constantly repeated until exited by a key-press or time-out loop.

If a key is pressed, the Hardware Control Manager turns control over to the User Interface. A key interpreter determines what action has been requested, and activates the appropriate subroutine. Once the requested task has been carried out, the User Interface may move on to another menu or return to Hardware Control.

You can use the Model 85 aScope just like it is. Or, you have the option of writing control programs in BASIC that, in effect, replace the User Interface portion of the operating software. In other words, you can control all the operations of the Model 85 aScope through BASIC.

HARDWARE CONTROL MANAGER
(User Interface)

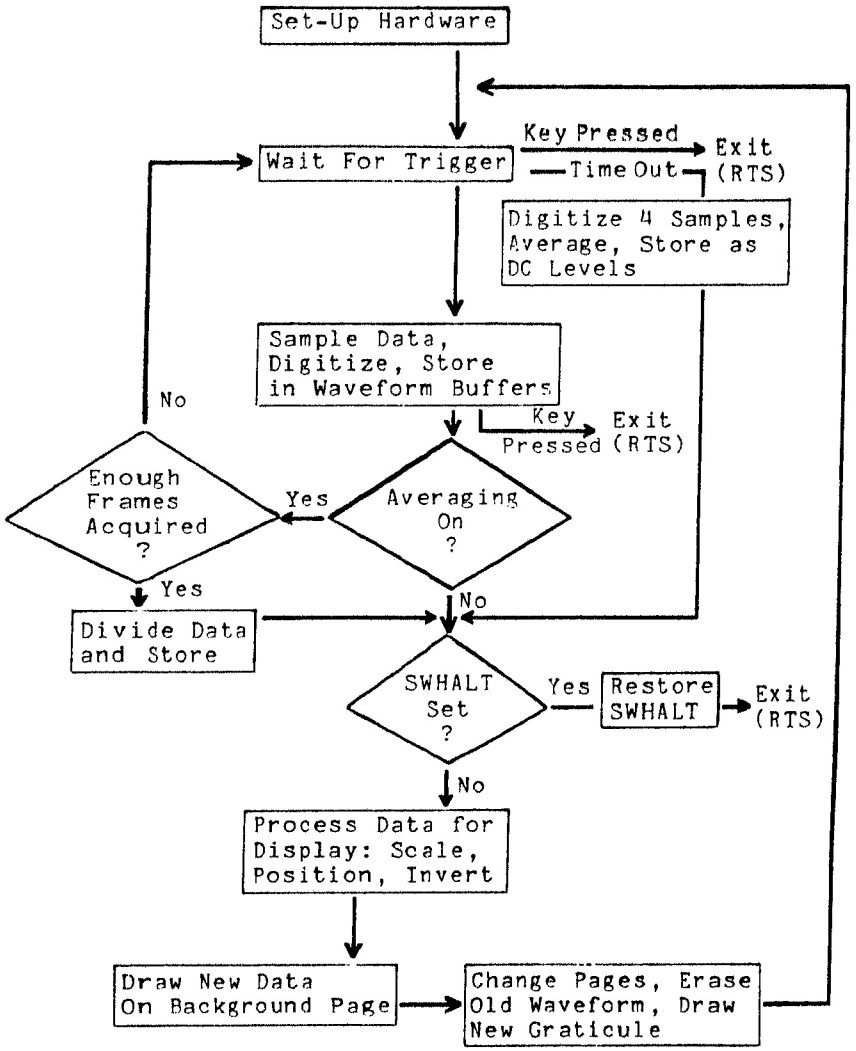


Figure VI-1. The Hardware Control Manager Program

USER INTERFACE

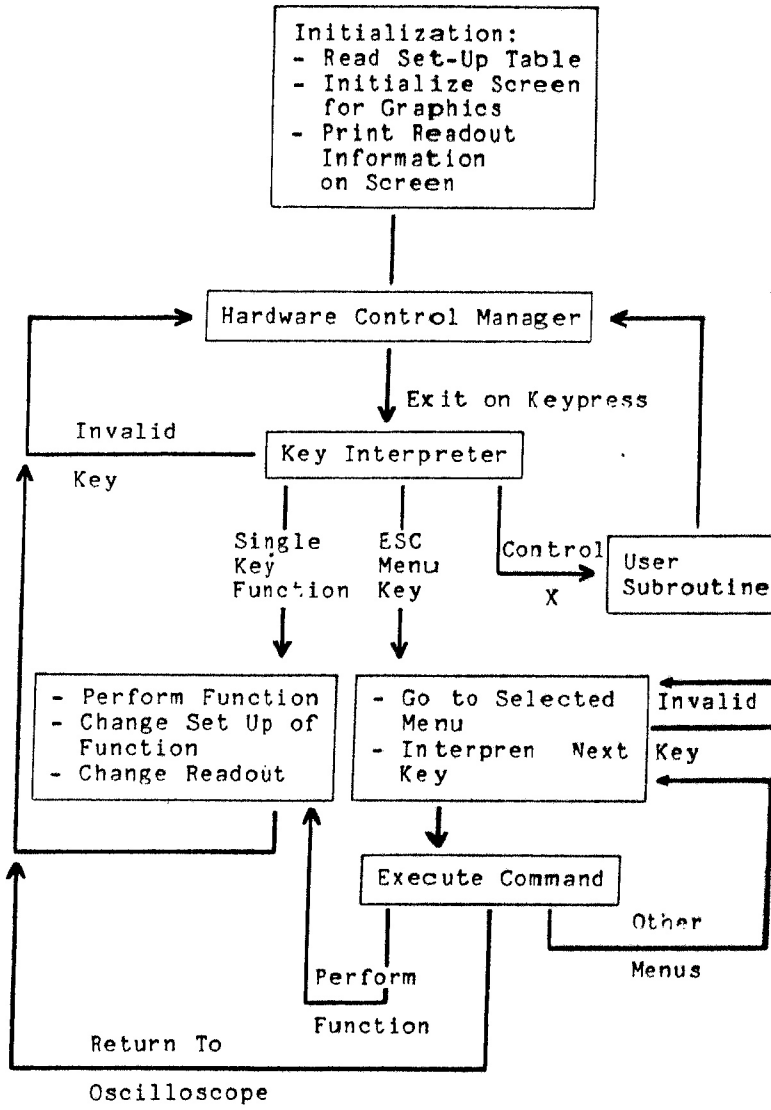


Figure VI-2. The User Interface program.

For example: Normally a trigger will initiate digitization, information processing, and display update. Then the Hardware Control Manager waits for the next trigger, and repeats the process. However, suppose you wanted to acquire only one waveform, and then return to your BASIC program. By writing your own control routines you can regain control of the Model 85 aScope after a single waveform acquisition.

In this section, we'll tell you how you can do just that. But first, a note about memory usage.

Memory Usage

All the Model 85 aScope operating software and waveform storage memory is contained in the 48K of Apple user memory. Figure VI-3 is a memory map of Apple user memory.

Since both high resolution graphics memory pages are used, the normal user's free space for BASIC and other programs is moved up from location $800 to location $6000. Any of your BASIC programs will load and run in this new location with no adjustment, provided that they do not exceed the available program space, which is approximately 8 K-bytes ($6000 to $7FE0).

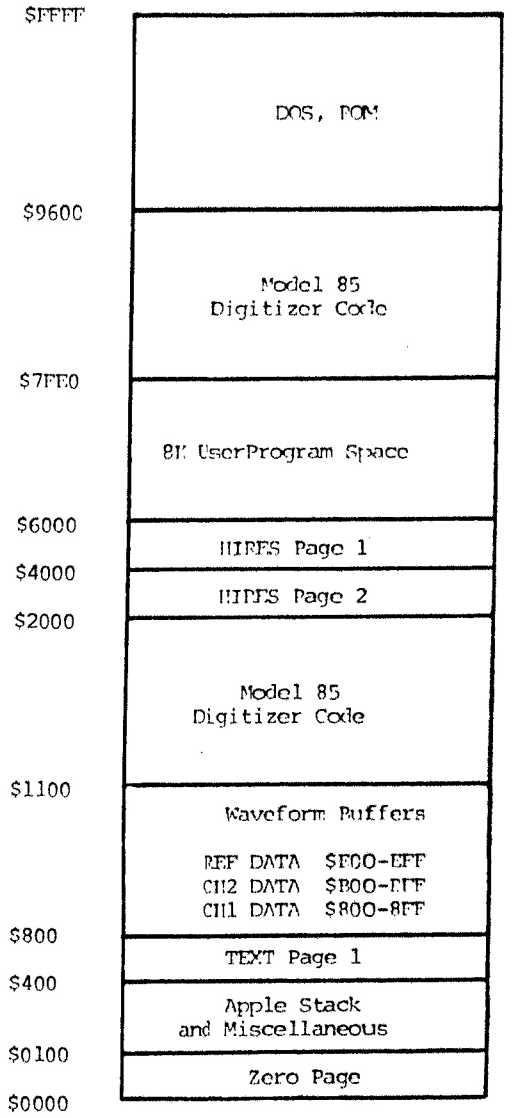


Figure VI-3. The Model 85 aScope memory map.

You must be sure not to modify HIMEM, LOMEM, or MAXFILES, however. See the appropriate Apple BASIC and DOS reference manuals for details on these commands, as well as information on how BASIC and DOS use memory.

Increasing Available RAM. The Model 85 aScope software routines are organized in a modular fashion, with priority assigned by the function which the routine performs. From high to low priority, the routines are shown in Table VI-1.

Table VI-1
Model 85 aScope Software Routines

Program Function	Routine	Start Address	End Address	Name of Disk File
	Initialize Routine	$0C00 3072	$1100 4352	INITIALIZE 85
	Set Up Data	$9518 -27368	$95FF -27137	SETUP 85
Hardware Control Manager	Digitizer Hardware Drivers	$9040 -28608	$9517 -27369	
	Display Routines	$8BC0 -29760	$903F -28609	HARDWARE CONTROL
	Control and Readout	$8630 -31184	$8BBE -29762	
	Menu Routines	$8328 -31960	$862F -31185	
	DVM	$7FE0 32736	$8327 -31961	
User Interface	Menu Text Tables	$1A10 6672	$1FFF 8191	USER INTERFACE
	Menu Routines	$1100 4352	$1A0F 6671	

The lower priority modules may be eliminated to provide more available RAM memory. This can provide you with more room for an applications program, for instance. If one of the Model 85 aScope modules is overwritten, that routine must, of course, never be called from the Operations Menu or from your own control program, or the system will do unpredictable things. In no case should the set-up data or the digitizer hardware drivers be overwritten.

When you have the Autostart ROM, and you boot the Model 85 aScope Operating Software, a program named "HELLO" is loaded and executed. This program loads three binary files (SETUP 85, HARDWARE CONTROL, and USER INTERFACE). "HELLO" then loads and runs the program "INITIALIZE 85". The "INITIALIZE 85" program must always be used to start the Model 85 aScope.

"INITIALIZE 85" performs three functions:

1. It reads a character table into locations $0D00 to $1100, and then stores these characters into the hidden locations of HIRES graphics pages 1 and 2.

2. It erases memory locations $6000 - $7FE0 where a user BASIC program would reside.

3. It resets the start-of-program pointer to $6000 and resets HIMEM to $7FE0.

After these operations are performed, "INITIALIZE 85" jumps to the digitizer and starts operation.

Writing Your Own Control Programs

The Model 85 aScope environment makes it easy to write control programs. All the acquisition functions of the oscilloscope are accessable by a BASIC program, or even by an assembly language program. Table VI-2 lists all the memory locations and contents that you can use in writing a control program.

As you can see from Table VI-2, you can access all the operations of the Model 85 aScope from a BASIC program by peeking and poking. Of course you can access these same locations from an assembly language program.

Remember the problem of returning to the BASIC program after acquiring one waveform? Lets look at how that could be done.

Returning to Your Program

Once your program has turned on the Model 85 aScope, there are three ways for you to gain back control: by pressing any key, by setting the SWHALT location to $80 (see Table VI-2), or by generating a non-maskable interrupt (NMI) on the Apple bus.

Pressing a Key. If the digitizer is waiting for a trigger, pressing any key will halt it immediately. The keyboard latch retains the last key pressed, and that value is returned to your program with the high bit set. If a key is pressed after the trigger, the acquired signal is processed and displayed before control is returned to your program.

Table VI-2
Control Locations

Name	Location (Hex)	Location (Decimal)	Value (Hex)
Graticule	$9524	-27356	$80 - ON $0 - OFF
Trigger Slope	$9530	-27344	$0 - +Slope $1 - -Slop
Trigger Source	$953C	-27332	$0 - CH1 $1 - CH2
Trigger Level	$9548	-27320	$0 to $7F Positive $80 - 0 Volts $81 to $FF Negative
Time Base	$9554	-27308	$03 to $1F for 10 ns/DI to 20 s/DIV
CH1 ON/OFF	$9560	-27296	$0 - OFF $1 - ON
CH1 Averaging ON/OFF	$956C	-27284	$0 - OFF $1 - ON
CH1 Normal/Invert	$9578	-27272	$0 - Normal $1 - Inver
CH1 AC/DC Coupling	$9584	-27260	$0 - AC $1 - DC
CH1 Position	$9590	-27248	$0 to $7F Above Center $80 - Center $81 to $FF Below Center
CH1 Attenuator	$959C	-27236	$14 to $1D for 5 mV/DIV to 5 V/DIV
CH1 Ground Reference	$95DD	-27171	$0 to $7F Negative $80 Ground $81 to $FF Positive
CH1 Probe	$9539	-27335	$0 - x1 $1 - x10 $2 - x100
CH2 ON/OFF	$95A8	-27224	$0 - OFF $1 - ON
CH2 Averaging ON/OFF	$95B4	-27212	$0 - OFF $1 - ON
CH2 Normal/Invert	$95C0	-27200	$0 - Normal $1 - Invert
CH2 AC/DC Coupling	$95CC	-27188	$0 - AC $1 - DC
CH2 Position	$95D8	-27176	$0 to $7F Above Center $80 - Center $81 to $FF Below Center
CH2 Attenuator	$95E4	-27164	$14 to $1D for 5 mV/DIV to 5 V/DIV
CH2 Ground Reference	$95DE	-27170	$0 to $7F Negative $80 Ground $81 to $FF Positive
CH2 Probe	$953A	-27334	$0 - x1 $1 - x10 $2 - x100
Printer Slot	$952B	-27349	$0 - $7
Disk Slot	$952C	-27348	$0 - $7
Disk Drive	$952D	-27347	$0 - $1

Table VI-2 (cont)
Control Locations

Name	Location (Hex)	(Decimal)	Value (Hex)
Number of Samples to Take for Averaging	$952E	-27346	$0 - $FF ($0 never times out)
Number of Acquisition Times to Wait Before Time Out	$952A	-27350	$0 - $FF ($0 never times out)
Keyboard Lock/Unlock	$9529	-27351	$0 - All Keys Work $80 - Only ^K Key Works
SWHALT	$9569	-27287	$80 - Halt After 1 Acquisition $0 - Continue
Reference Display ON/OFF	$903D	-28611	$0 - OFF $80 - ON
Reference Channel	$95F6	-27146	$0 - CH1 $1 - CH2
Reference Averaging ON/OFF	$95F1	-27151	$0 - OFF $1 - ON
Reference Normal/Invert	$95F2	-27150	$0 - Normal $1 - Invert
Reference AC/DC Coupling	$95F3	-27149	$0 - AC $1 - DC
Reference Position	$95F4	-27148	$0 to $7F Above Center $80 - Center $81 to $FF Below Center
Reference Attenuator	$951E	-27362	$14 to $1D for 5 mV/DIV to 5 V/DIV
Reference Ground Reference	$95DF	-27169	$0 to $7F Negative $80 Ground $81 to $FF Positive
Reference Probe	$953B	-27333	$0 - x1 $1 - x10 $2 - x100
Reference Time Base	$95F5	-27147	$03 to $1F for 10 ns/DIV to 20 s/DIV

In general, pressing any key will interrupt the digitizer and return control to your program. The exception is the "ESC" key when averaging is on. "ESC" sets a flag which forces a return to your program after all samples have been taken and the necessary averaging computations have been made. Thus, exiting from averaging by pressing the "ESC" key will place the averaged waveform data in the channel's data buffer, while any other key is likely to yield only the latest, unaveraged, sample. In this exit mode, the system requires as a minimum the routine's Set-Up Data, Digitizer Hardware Drivers, and Display Routines described in Table VI-1.

Setting SWHALT. Setting SWHALT to $80 causes the digitizer to acquire one waveform, and return to your program. SWHALT is reset to zero by the Hardware Control Manager, and must be reset before the next program call. This exit mode requires only the Set-Up Data and Digitizer Hardware Drivers as a minimum system.

Generating an NMI. Generating an NMI will halt the Hardware Control Manager immediately, and branch to the Apple interrupt handling routine. Because you generally have no way of knowing at what point in the software the interrupt occurred, your control program should not try to continue executing. Many parts of the Model 85 aScope software have critical timing, and returning to these points from an NMI will produce unpredictable results. Further details on NMI action can be found in the Apple II Reference Manual.

User Definable Subroutines

In addition to the exit methods listed in the previous paragraphs, there are two user definable subroutine calls available: one within the Model 85 aScope User Interface, and another within the Hardware Control Manager. You can load Model 85 aScope memory with the location of a subroutine for each of these exit points.

User Interface Exit. Recall from Section III that you can enter a ^X keypress to access a subroutine. The address of your subroutine is loaded into location $8A31-2. Remember, the low byte is loaded first, followed by the high byte. When ^X is pressed, the Model 85 aScope will complete the digitizing and display cycle, and then jump to the subroutine address contained in location $8A31-2.

Hardware Control Manager Exit. If the address of a subroutine is loaded into location $927B-C, the Model 85 aScope will acquire a signal and digitize it, and then jump to the subroutine. No processing or display is achieved until the subroutine is completed. If you have some special data processing, such as subtracting a reference waveform from the data, or performing a transform, use $927B-C.

Subroutines

A variety of subroutines are available in the Model 85 aScope software to make writing your own BASIC or machine language interface program easier. Table VI-3 lists the subroutines that you can call from your program.

Table VI-3
Subroutines

Location (Hex)	Location (Decimal)	Function
$90F0	-28432	Digitizer (via Hardware Control Manager)
$8FDD	-28707	Erase (erases both hires pages)
$8D15	-29419	Graticule (draws on both hires pag
$8328	-31960	Hard Copy (MX-80 with graphics option or equivalent) $903E (next page) will be set to copy the last displayed page. Put $40 here to copy page 1, and $20 to copy page 2.
$8E20	-29152	Display Waveform on Next Page
$8554	-31404	Hires Character Generator (outputs one character on selected page) The following locations should be set before calling the hires character generator: $903F PAGE $20 for page 1, $40 for page 2; $5178 CHAR ASCII Code; $5179 HPOS 0-39 column; $517A VPOS 0-23 row; $8553 VOFFSET 0-7 vertical offset within row

Using the Model 85 Subroutines

You can access the various modules comprising the Model 85 aScope operating software by creating a control program. Your control program can be written in BASIC or in machine language. When your program calls a subroutine, the subroutine will return control at completion.

The Subroutines

DIGITIZER. This routine acquires data on both channels (whether they are turned on for display or not). Data is stored in the CH1 and CH2 waveform buffers. If waveform averaging is turned on for one channel and not for the other, then the last acquired waveform of the non-averaged channel will be stored. For instance, if waveform averaging is set to average 10 frames and turned on for CH1 only, 10 frames will be acquired on both channels. On CH1 they will be averaged and the result returned to the CH1 waveform buffer. On CH2, the 10th frame will be stored in the CH2 waveform buffer.

When called normally, the digitizer will acquire data and display it repeatedly. Pressing any key will interrupt the digitizer. By setting location SWHALT to 128 ($80) or greater, calling the digitizer will cause one frame of data to be acquired and returned without display. If averaging is selected, the number of frames selected will be acquired and the average returned.

Ordinarily, calling DIGITIZER enters the digitizer loop in the same way as the User Interface program, and will digitize and display until a key is pressed. To prevent the display function or to digitize one waveform and return, set SWHALT to 128 each time you call DIGITIZER.

ERASE. This routine completely erases both HIRES pages. When control returns to your program, you're operating with the same page, either text or graphics, as was the case before the ERASE routine was called.

NOTE

If you wish to erase both HIRES graphics pages, it is imperative that you do not use the HGR command from BASIC. The Model 85 aScope stores characters in the unused

locations of both HIRES pages. The HGR command will erase these characters. Instead of HGR, use a jump to subroutine ERASE. If plotting on the HIRES pages from Applesoft is required, simply erase using subroutine ERASE, then POKE 230,32 (for plotting on HIRES page 1), or POKE 230,64 (for plotting on HIRES page 2). The HPLOT commands will then operate normally, and the Model 85 aScope characters will be preserved.

GRATICULE. This subroutine draws the 8 x 10 division scope graticule on both HIRES pages.

HARD COPY. This subroutine sends the last displayed HIRES page to the printer located in the slot specified from the Hard Copy menu. The data is sent in the Epson MX-80 format. If you need to print a specific HIRES page, you can use POKE -28610,64 for HIRES page 1, or POKE-28610,32 for HIRES page 2 before calling HARD COPY. If you have some type of printer other than the Epson MX-80 or the Apple Silentype, you may wish to install your own printer driver software. An assembly language subroutine may be substituted for the existing hardcopy routine located from $8328 to $83B9. Or, you can modify the first instruction of the hardcopy routine at $8328 to be a jump to an assembly language program located elsewhere.

DISPLAY. This subroutine plots only the channels which are turned on. Those channels are plotted on the page pointed to in location -28610 You can change the contents of location -28610 to specifically use HIRES page 1 or page 2, just as with the HARD COPY subroutine.

HIRES CHARACTER GENERATOR. This subroutine will plot characters on the HIRES page at locations specified by you. Labels, text, and headers can all be added to the displays by using HIRES CHARACTER GENERATOR. Table VI-4 lists the locations that should be set

before calling the character generator.

Table VI-4
HIRES Character Generator Locations

Location	Definition	Explanation
-28609	PAGE	Set to 32 for page 1, 64 for page 2
20856	CHAR	ASCII code of character to plot
20857	H	Column for plotting (0-39)
20858	V	Row for plotting (0-23)
-31405	VOFFSET	Vertical offset with the row (0-7, normally 0)

Following is an example of one way to use the HIRES CHARACTER GENERATOR in a BASIC program.

```
10    H= 20857:V= 20858:CHAR= 20856: REM Define
      locations
20    POKE -31405,0: REM  Set vertical offset to 0
30    POKE -28609,32: REM  Set to Page 1
40    T1$="TEST"
50    T2$="LABEL": REM  Set up strings
60    POKE -16304,0:POKE -16301,0:POKE -16297,0: REM Turn
      on HIRES page
70    ST$=T1$:HO=2:POKE V,5: REM HO is horizontal
      offset
80    GOSUB 1000
90    ST$=T2$:HO=2:POKE V,7
100   GOSUB 1000: REM  Jump to output subroutine
110   END
1000  FOR I=1 TO LEN(ST$): REM Set loop to output
      character by character
1010  POKE H,I+HO: REM  Set horizontal position
1020  POKE CHAR,ASC(MID$(ST$,I,1)): REM Select character,
      and output character code
1030  CALL -31404: REM  Call character generator
1040  NEXT I:REM  Next character
1050  RETURN
```


To run the example BASIC program, load the Model 85 aScope operating software. Once the software is loaded, press the "ESC" key to get the Operations Menu, then the "G" key to get the Miscellaneous Menu. From the Miscellaneous Menu, enter "F" to escape to BASIC. Load the BASIC program and run it. The program will plot your label "TEST LABEL" on the HIRES page along with the waveform overlay.

Examples

The remainder of this section contains three programming examples. All use BASIC to access and control the Model 85 aScope, and all illustrate how you can control the features of the oscilloscope. These examples are saved on the Model 85 aScope system Operating Software disk under the names "PROGRAM 1", "PROGRAM 2", and "PROGRAM 3".

Example 1

This program is a simple example of a user interface program. This program initializes the digitizer to take 2 ms/DIV real-time signals from Channel 1 with an attenuator setting of 100 mV/DIV, normal polarity, and AC coupling. The trigger is from Channel 2, from signals crossing 40 mV with a positive slope. Five such signals are to be acquired and stored as text files under the names "EXPERIMENT n", where n = 1 to 5. A hard copy will be generated from acquisition 5.

```
10    REM  INITIALIZATION
20    BASE = -27356: REM $9524 IS THE BASE LOCATION
         SET-UP DATA
30    DATA 80,0,1,132,19,1,0,0,0,12,
         8,24,0,0,0,0,128,24
```

```
40    FOR I = 0 TO 192 STEP 12
50    READ X
60    POKE BASE + I,X
70    NEXT I
100   REM ACQUIRE 5 SIGNALS AND SAVE DATA
110   SWHALT = -27287: REM $9569
120   DIGITIZER = -28432 :REM $90F0
130   D$ = CHR$ (4): REM CONTROL-D
140   FOR I = 1 TO 5
150   POKE SWHALT,128
160   CALL DIGITIZER
170   PRINT D$;"BSAVE EXPERIMENT "; STR$ (I);
        "A$800,L$100"
180   NEXT I
200   REM DRAW LAST WAVEFORM, THEN MAKE HARD COPY
210   ERASE = -28707: REM $8FDD
220   DSPLAY = -29152: REM $8E20
230   CALL ERASE
240   CALL DSPLAY
245   POKE -16300,0: REM RESTORE PAGE 1
250   HARDCOPY = -31960: REM $8328
260   N = 1: REM PRINTER SLOT
270   PRINT D$;"PR#";N
280   PRINT "EXPERIMENT ";I -1
290   PRINT : PRINT
300   CALL HARDCOPY
310   PR# 0
320   END
```

Example 2

The second example loads a set-up file called "ORIGINAL SETUP 85" which establishes the control settings of the digitizer. The set-up acquires Channel 1 and Channel 2 signals. The program calls the graticule routine, then uses Applesoft graphic commands to plot Channel 1 vs Channel 2. A hard copy is produced at the end. Note that since this program does not use the high resolution character generator, we can use the "HGR" command without problems.


```
10    REM  INITIALIZATION
20    D$ = CHR$ (4):REM CONTROL D
30    PRINT D$;"BLOAD ORIGINAL SETUP 85"
40    DIGITIZER = -28432: REM $90F0
50    SWHALT = -27287: REM $9569
60    POKE SWHALT,128
70    CALL DIGITIZER
100   HGR
105   HCOLOR = 3
110   GTICULE = -29419: REM $8D15
120   CALL GTICULE
130   C1 = 2048: REM $800
140   C2 = 2816: REM $B00
150   FOR I = 0 TO 255
160   X = 255 - PEEK (C1 + I): REM DATA IS STORED
        WITH $0 = MOST POSITIVE VALUE, SO X MUST
        BE INVERTED FOR PROPER DISPLAY.
170   Y = INT ( PEEK (C2 + I) * (5 / 8)): REM
        APPLE PLOTS WITH 0,0 AT UPPER LEFT, SO
        Y DOES NOT NEED INVERSION.  IT DOES NEED
        TO BE SCALED TO THE PLOTTING RANGE OF
        0 TO 159
180   HPLOT X,Y
190   NEXT I
300   HARDCOPY = -31960: REM $8328
310   HPAGE = -28610: REM $903E $40 FOR PAGE 1
        AND $20 FOR PAGE 2.
320   POKE HPAGE,64: REM SET PAGE 1
330   CALL HARDCOPY
340   END
```

Example 3

In the final example, a reference waveform named "NOMINAL SIGNAL" is loaded into the reference display page. Channel 2 is turned off, but is used for triggering. Channel 1 is turned on and the reference display is enabled. The digitizer is then called. If the "Y" key is pressed, control passes to a user subroutine called "TEST PASSED". If "N" is pressed,

control passes to a subroutine called "TEST FAILED".

```
10    REM  INITIALIZATION
20    D$ = CHR$ (4):REM CONTROL D
30    PRINT D$;"BLOAD ORIGINAL SETUP 85"
40    PRINT D$;"BLOAD NOMINAL SIGNAL,
        A$E00"
50    01 = -27296: REM $9560 CH1 ON/OFF
60    02 = -27224: REM $95A8 CH2 ON/OFF
70    REF = -28611: REM $903D REFERENCE
        WAVEFORM ON/OFF
80    RCHAN = -27146: REM $95F6 0 FOR
        REFERENCE ON CHANNEL 1, 1 FOR
        REFERENCE ON CHANNEL 2
90    POKE 01,1: REM CH1 ON
100   POKE 02,0: REM CH2 OFF
110   POKE REF,128: REM REFERENCE ON
120   POKE RCHAN,1: REM REFERENCE ON CH2
130   DIGITIZER = -28432
140   KYBOARD = -16384: REM $C000 KEYBOARD INPUT
150   KSTROBE = -16368: REM $C010 KEYBOARD
        STROBE RESET
152   POKE -16297,0: REM SET HIRES GRAPHICS
153   POKE -16302,0: REM SET FULL SCREEN
        GRAPHICS
154   POKE -16304,0: REM TURN ON GRAPHICS
155   ERASE = -28707: REM $8FDD
157   CALL ERASE
160   CALL DIGITIZER
170   X = PEEK (KYBOARD)
180   POKE KSTROBE,0: REM WE ONLY GET HERE IF
        A KEY WAS PRESSED
190   X$ = CHR$ (X - 128)
200   IF X$ = "Y" THEN GOSUB 1000
210   IF X$ = "N" THEN GOSUB 2000
220   GOTO 160: REM SOME KEY OTHER THAN Y OR N
        PRESSED
1000  REM TEST PASSED - USER FUNCTION HERE
1010  TEXT
1020  END
2000  REM TEST FAILED - USER FUNCTION HERE
2010  TEXT
2020  END
```


Section VII

HARDWARE DETAILS

Introduction

Two printed circuit boards form the Model 85 aScope digital memory oscilloscope: the horizontal time-base board, and the vertical input channel board. The horizontal time-base board is on your left as you view the Apple from the front.

A block diagram of the Model 85 aScope hardware is shown in Fig. VII-1.

The Input Channels

Each input channel has a separate, independent input attenuator, amplifier, and sample and hold circuit. The Hardware Control software sets up the system for each sample. The sample is then taken simultaneously on both channels, under the control of the sampling time-base for equivalent time sampling, or under control of software for real-time sampling.

The software then steers the sample from each channel in turn through the multiplexer (MUX) and programmable gain amplifier (PGA) to the analog-to-digital (A/D) converter. The digitized sample is then stored by software into buffer memory in the Apple. This sequence is repeated until all 256 waveform data points are recorded.

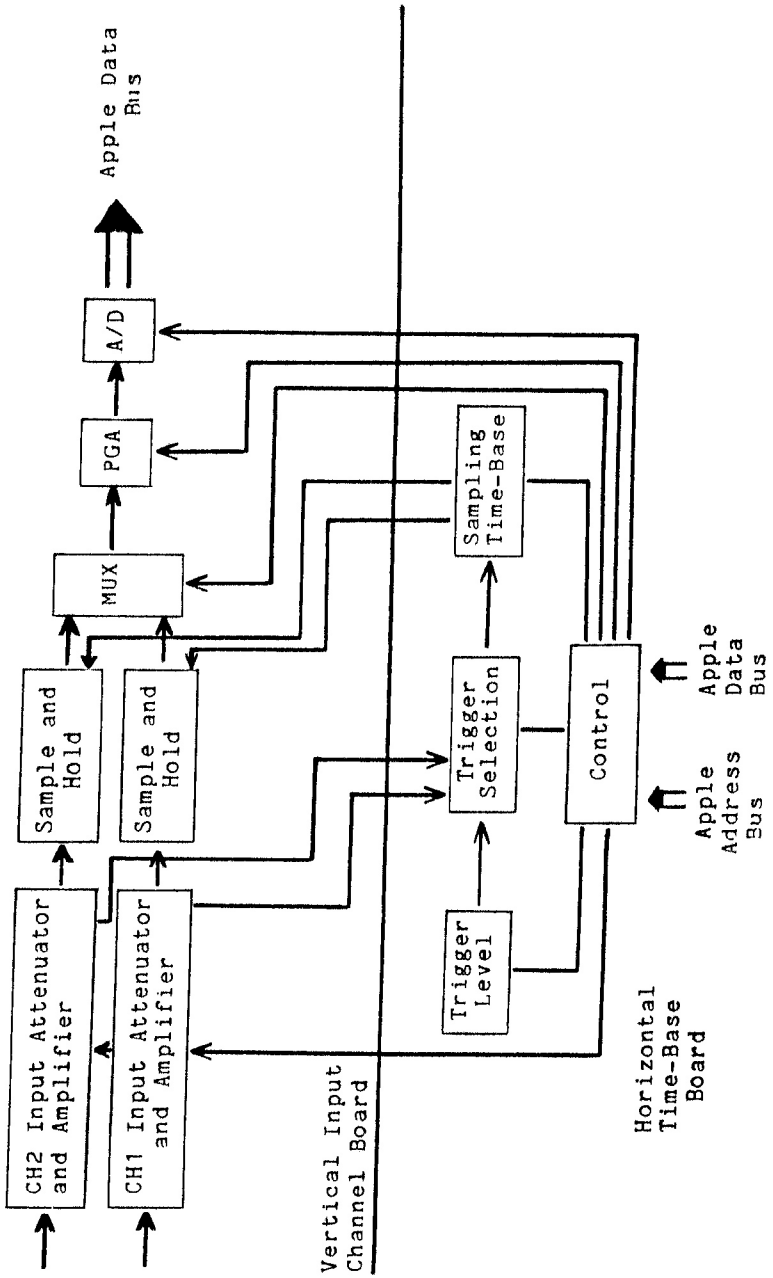


Figure VII-1. Model 85 aScope block diagram.

The A/D Converter

The A/D converter has a resolution of 8 bits (256 levels). Digitized data is recorded with the full 8-bit resolution of the converter on all vertical attenuator settings. Signals exceeding the maximum that can be displayed on any particular attenuator setting will be clipped to the maximum. For display the 256 levels are scaled down to 161, so several points on the screen correspond to more than one actual data value. Calculations on the waveform dat should use the full scale data.

Attenuators

The attenuator on the input of each channel reduces the input signal level interally by a factor of 20 for attenuator settings of 500 mV/DIV to 5 V/DIV. Since the trigger signal is extracted from the signal path after the attenuator, the trigger signal level is also reduced, and this is reflected in the trigger level set-up display. In some cases, a signal which will trigger satisfactorily on a 200 mV/DIV range may require trigger level adjustments at 500 mV/DIV.

Trigger Level

The trigger level voltage, as displayed, is only relatively calibrated and should be used as an indication only. The trigger level voltage steps of 10 mV for 5 mV/DIV to 200 mV/DIV, and 200 mV for 500 mV/DIV and up, are accurate step sizes, but the indicated voltage is only an approximation to the actual trigger level. Thus, some adjustment of trigger set-up may be required for reliable acquisition of some signals.

Section VIII

INSTRUMENT SPECIFICATIONS

TIME BASE

Range: 10 ns/division to 20 s/division, programmable in 1-2-5 sequence. 10 ns/division to 500 us/division equivalent time, 1 ms/division real-time alternate channel acquisition, 2 ms/division to 20 s/division real-time simultaneous-channel acquisition.

Trigger Mode: Normal (sweep runs when triggered). Auto (low rate sampling in order to display a dc trace when the trigger is absent).

Trigger Level: ±1.26 V programmable in 10 mV steps for 5 mV/division to 200 mV/division. ±25.2 V programmable in 200 mV steps for 500 mV/division to 5 V/division.

Slope: Plus or minus slope, programmable.

Source: Channel 1 or Channel 2 trigger, programmable.

Mode: Equivalent time for sweeps faster than 1.0 ms/division, real-time for slower sweeps.

Accuracy: Within ± 3%

DISPLAY

Format: Channel 1 only, Channel 2 only, or dual channel.

Graticule: Software generated, on/off on command.

Update: Continuous display, halt on demand.

OPERATING CHARACTERISTICS

Ambient Temperature: 25°C ± 10°C

Power Dissipation: 4.0 W typical.

Compatibility: Apple II* or Apple II Plus* with 48K RAM and Disk II and DOS 3.3.

Software: Operating software on disk. Uses 9.3 K for the complete operating system, 2.3 K for data and display buffers, and 16 K in two high resolution display pages. Approximately 8 K of memory remains as contiguous user space.

INPUT CHANNELS

Modes: Channel 1 only, Channel 2 only, Channel 1 and Channel 2 (dual channel).

Bandwidth: DC to greater than 50 MHz equivalent time digitizing (-3 dB). DC to greater than 10 KHz resolvable with real-time digitizing (-3 dB).

Rise Time: 7.0 ns or less equivalent time digitizing. 40 us or less resolvable with real-time digitizing.

Input Impedence: 1MΩ and 20 pF.

Accuracy: Within ±3%

Maximum Input Voltage: ±5 V for input attenuator settings of 5 mV/division to 200 mV/division, ±100 V for input attenuator settings of 500 mV/division to 5 V/division.

Input Signal Voltage: ±1 V peak-to-peak maximum for input attenuator settings of 5 mV/division to 200 mV/division. ±20 V peak-to-peak maximum for input attenuator settings of 500 mV/division to 5 V/division.

Sensitivity: 5 mV/division to 5 V/division,

programmable in 1-2-5 sequence.

Ground Reference: Achieved through probe ground reference switch.

Coupling: DC or AC, programmable.

Display: Normal or inverted, programmable.

DIGITIZER AND MEMORY

Method: Equivalent time digitization (sampling) for sweep speeds of 500 us/division and faster, real-tim digitization for 1 ms/division and slower (25 KHz sampling rate).

Resolution: 8 bits (1 part in 256)

Memory Size: Record length is 256 samples for each channel.

WAVEFORM PROCESSING

Waveform Averaging: Average 2 to 255 frames.

Cursor: DVM readout through single movable cursor on both channels.

Hard Copy: Hard copy output software provided for Epson MX-80 with graphics option, Apple Silentype.

Waveform Storage: Store waveforms and instrument set-up on disk.

Reference Waveform: Recall a stored waveform for comparison to a measured waveform.

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MODEL 85 KEYBOARD CONTROL

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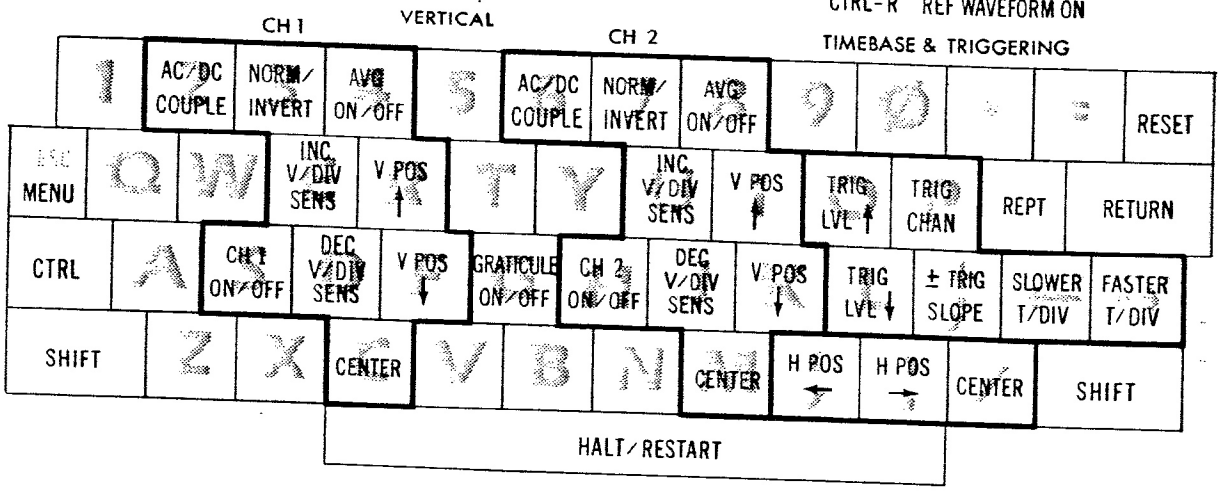
CTRL-X USER SUBROUTINE
CTRL-R REF WAVEFORM ON



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